Chapter 48
MAC Protocol for CRSN

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ABSTRACT

Cognitive Radio (CR) technology has gained popularity in Wireless Sensor Networks (WSN) because of scarcity caused by the increase in number of wireless devices and service, and it provides spectrum-efficient communication for the resource constrained WSNs. However, appropriate protocols have to be devised to satisfy the requirements of both WSNs and CRs and to enjoy the benefits of cognition in sensor networks. In this chapter, the authors review the existing schemes for wired, wireless, and cognitive radio networks. In addition, they propose a novel energy-efficient and spectrum-aware Medium Access Control (MAC) protocol for the cognitive radio sensor network. The authors design a spectrum-aware asynchronous duty cycle approach that caters to the requirements of both the domains. The performance of the proposed MAC is evaluated via simulations. Performance evaluations are also compared with MCMAC, a multi-channel MAC for WSNs. The comparative results show that the proposed scheme outperforms the multi-channel scheme for WSN.

INTRODUCTION

A wireless sensor network comprises a network of spatially distributed autonomous sensors. The sensor nodes have the ability to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. In addition, sensor nodes can cooperatively pass their data through the network to a main location, also known as base station. Each sensor node, in turn, consists of several parts, such as a radio transceiver, antenna, microcontroller and battery. Due to recent advancements in microelectromechanical systems, the size and cost of the sensors have decreased. More importantly, these sensors have the capability to wirelessly communicate with each other. Sensor nodes are usually deployed in a network to sense the environment, which, upon occurrence of an event, generate and forward reports over the network to be received by a sink node.

In addition, wireless sensor networks (WSNs) are flexible, fault tolerant, low-cost and can be rapidly deployed. These characteristics of WSNs enable many exciting applications for remote sensing, industrial automation, defense applications and utility metering. For example, some famous defense applications are monitoring friendly forces, battlefield surveillance, battle damage assessment and nuclear, biological and chemical attack detection. Environmental applications of WSNs include chemical and biological detection, as well as tracking the movement of birds, animals and insects. A wide variety of home and commercial applications are available, such as home automation, environmental and traffic monitoring etc.

However, sensor networks needs to resolve the constraints introduced by factors such as link connectivity, limited bandwidth and processing capability. Moreover, the event-driven nature of communication in WSNs generally yields a 'bursty' type of traffic, which results in under-utilization of the transmission medium. Therefore, it is inefficient to use a fixed scheme of channels allocated for these sensor nodes.

Spectrum bands are mostly allocated to fixed services. However, it is seen that some portions of the bands allocated to fixed services have become very crowded while other portions of the band remain vacant. The under-utilization of the resources generates a need to allocate the available resources more efficiently. Frequency re-use in the form of spectrum sharing can help mitigate the issues such as interference and congestion in bands allocated to fixed services. Research on these issues has led to the development of cognitive radio (CR).

Cognitive radio networks (CRNs) consists of primary users (PUs) and secondary users (SUs). In CRNs, PUs are licensed to access the band and are prior to SUs which do not have a license to use the band. CR is a technique which senses the bands, determines the idle bands and makes use of the available bands to transmit data. CRs can operate in both licensed and unlicensed spectrum. In the licensed bands, a SU, also called CR user, is given access only when it is not occupied by the Primary User (PU). SUs can access the band as long as they do not interfere with the PUs. The use of cognitive radios in recent communication technologies is motivated by its ability to dynamically access the available bands in the licensed spectrum. This allows the cognitive radio enabled wireless devices to adapt to the spectrum allocation, thereby improving the spectrum utilization.

The use of CR networks (CRNs) in WSNs has led to the development of Cognitive Radio Sensor Networks (CRSNs), which is an attempt to merge the beneficial aspects of WSNs and CRNs. As indicated in (Akan, Karli, & Argul, 2009) and (Vijay, Ben Ali Bdira, & Ibnkahla, 2011), cognitive radio enabled wireless sensor networks can make communication more reliable by reducing congestion and excessive packet loss. Cognitive radio enable sensor networks has helped meet the unique requirements and challenges of WSNs which are commonly assumed to use fixed spectrum allocation and are marked by resource constraints in terms of communication and processing capabilities. Sensor nodes enabled with cognitive radios can therefore access multiple alternative channels to mitigate the associated issues.

CRSN is a promising approach for communication, especially in the ISM band, where the radio spectrum is overcrowded. However, combining CRNs and WSNs also gives rise to a new set of issues which adversely affects the power consumption level, network and interference faced by the sensor nodes. By restricting spectrum access, developing energy efficient and spectrum aware MAC for CRSN becomes a challenging task.

It is to be noted that existing MAC protocols for WSNs cannot used as the CRSN node must now address to additional features such as spectrum sensing periods, broadcast over a common channel, and the need for a high-priority access mechanism for the distribution of spectrum sensing and decision results.

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